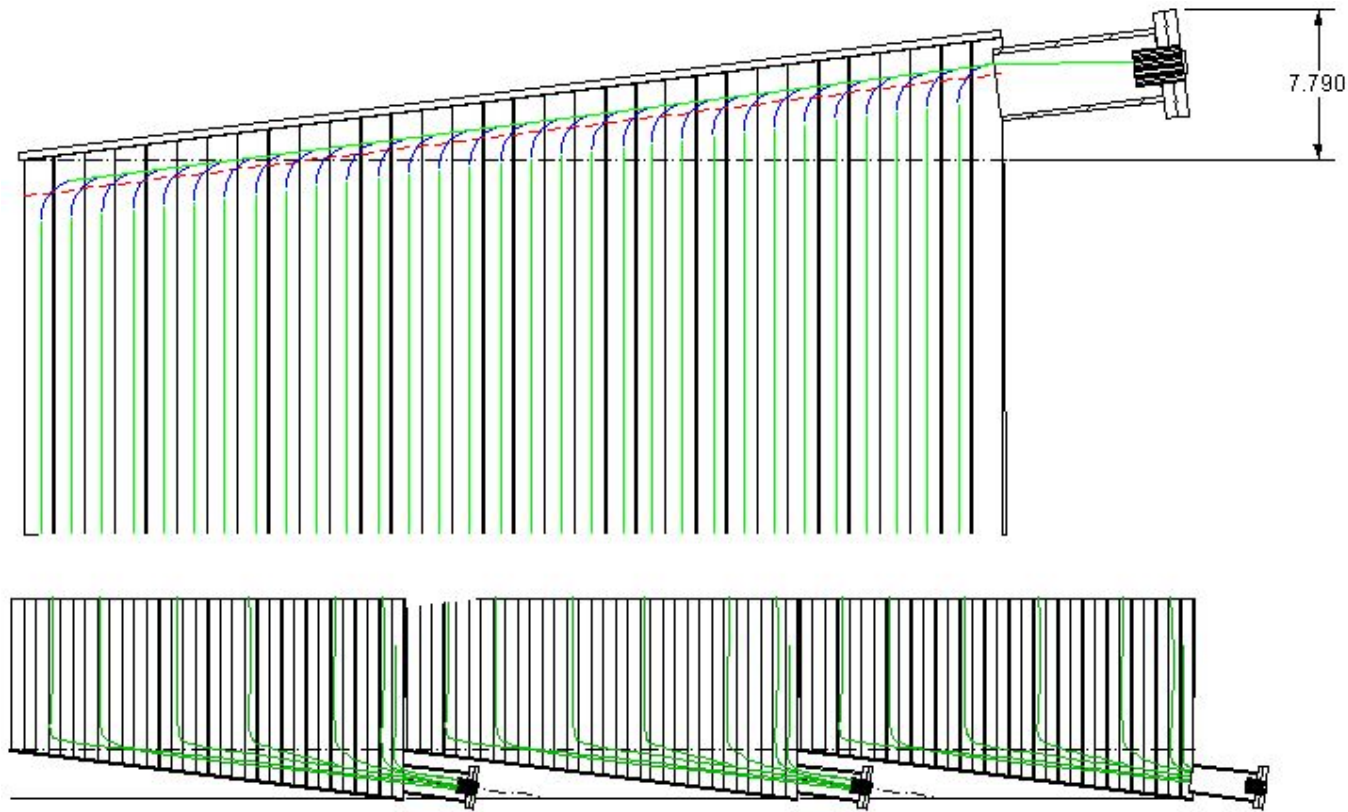


The Monolithic Manifold

Nova in the North Meeting,

May 22 to May 25, 2006

Hans Jostlein

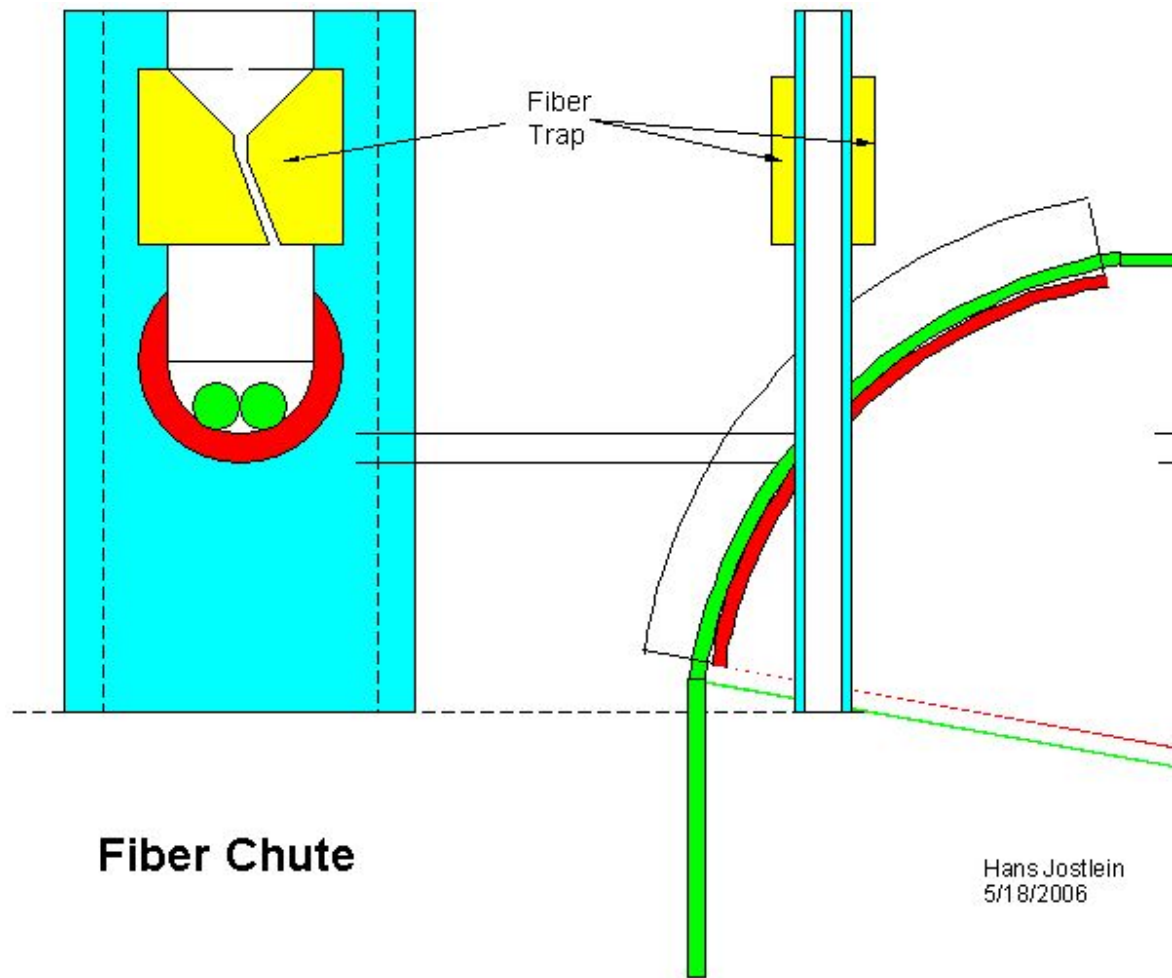


Monolithic Manifold

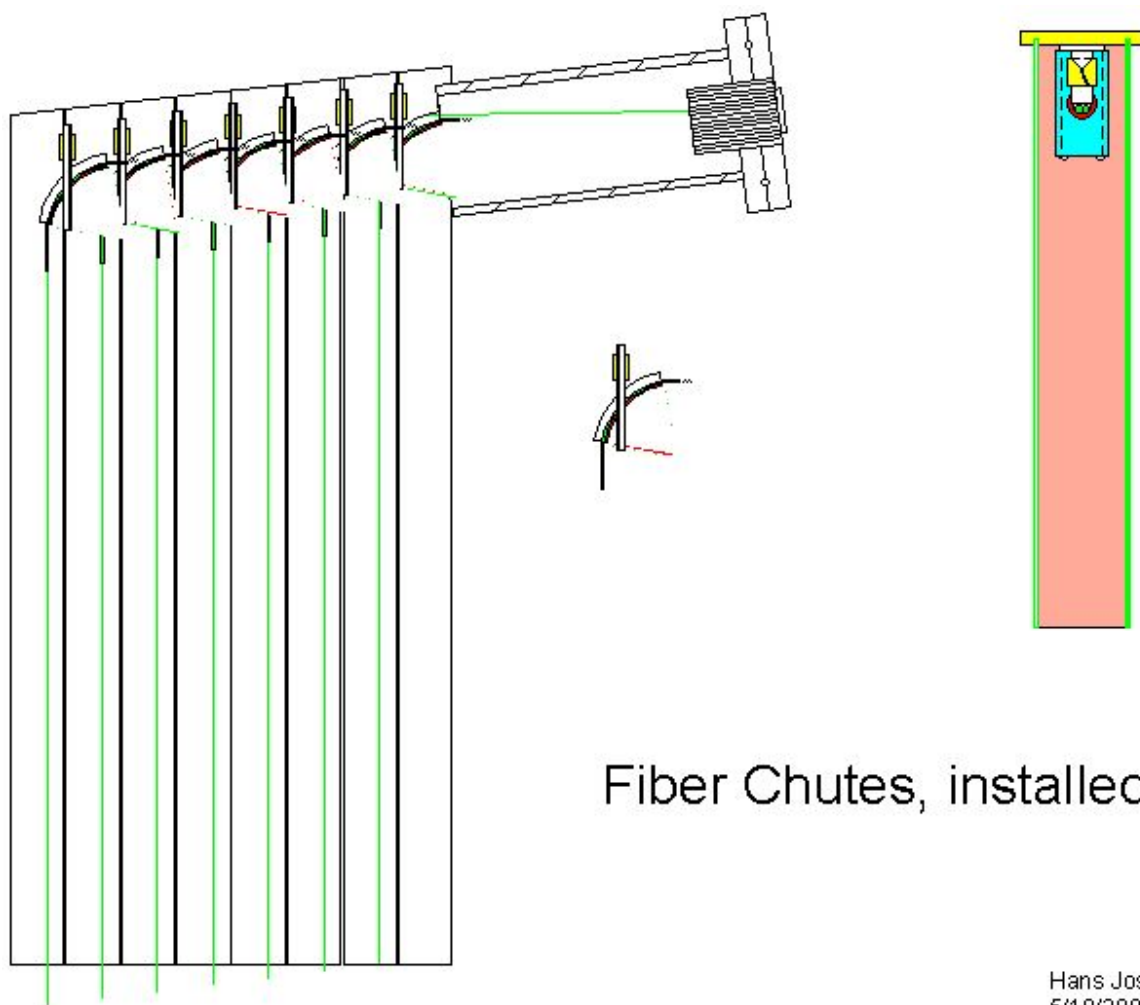
Hans Jostlein
5/16/2006

Synopsis of Features

1. Use the inherent strength of extrusion as the shell
2. Make fiber installation easy and foolproof
3. Introduce "Fiber chutes".



- a.
- b. The fiber chutes guarantee sufficient fiber bending radius;
- c. Have a simple “fiber trap” to channel fibers and fiber bundles
- d. Do not require any gluing
- e. Are easy and inexpensive to produce
- f. Make use of hand held notching tools to make quick and chip-free slots and openings (Dzero experience)
- g. Are trapped by the end plate
4. Sturdy snout piece with a solid flange to mount electronics box
 - a. Easy fiber feeding through the snout
 - b. Fool proof sequential fiber insertion into cookie, in full view
5. Use an endplate identical to the bottom plate (and equally “bullet proof”)
6. Create a sturdy surface, safe to walk on
7. Both ends of the module are extremely rugged, as needed for truck shipping
8. Maximize useful extrusion overlap length, minimize “overhead length”
9. Use a minimum of glue seams
10. Use captured glue joint, except for the snout piece
11. Only two types of molded parts, the snout and the fiber chutes.



Fiber Chutes, installed

Hans Jostlein
5/19/2006

a. Each fiber pair must go to the correct pair of holes in the connector.
(Fibers within a pair can be interchanged)

b. Fibers must be prevented from being forced into a too tight bend under reasonable forces

c. Forces include gravity and installation handling forces.

Gravity forces are very small, about 23 psi which translates into 9 grams force for an 0.8 mm diameter fiber.

Installation forces can easily be ten times higher, so we need to design for something like 100 g force per fiber.

Backup Materials:

Tom Chase :

I'll start with the bottom seal first.

We have two competitive designs for the bottom seal: a machined version and an injection molded version.

Both of these versions are very much in the running as of today.
To itemize all of the possibilities:

- 1) We could use machined bottom seals on all modules.
- 2) We could use injection molded seals on all modules.
- 3) We could use machined bottom seals on vertical modules and injection molded seals on horizontal modules. (This has implications in that the vertical and horizontal modules are no longer identical.)

Two factors will be used to finalize this decision:

- 1) The final seal(s) must meet performance requirements for strength and providing a liquid tight seal
- 2) The final seal(s), after satisfying the performance requirements, should also provide the lowest cost (in terms of both part cost and installation cost).

I am pleased that your FEA work indicates that the injection molded option appears promising on the structural side. At your convenience, could I obtain a copy of your analysis?

We have initiated experiments here to determine the seal quality and provide additional experimental data on the seal strength. We are considering both machined and injection molded options. Our first experiments are using machined seals, but we will follow up with (machined simulations of) injection molded seals, also.

I will be developing a detailed costing of both options over the next couple of months.

Hans Jostlein Comments

>> time studies on machining the bottom plates here on our Fermilab CNC routers. The studies were done with rotating router bits that will not leave the open grooves that the saw blades made.
The pattern was for the current scalloped design.

Tom Chase's Evaluation:
Two prototypes have also been presented for the top manifold:

- 1) A design where the fiber threading takes place external to the extrusion.
- 2) A design where the fiber threading takes place within the extrusion.

These options must be evaluated on the basis of:

- 1) Structure, including module strength, liquid seal quality and protection of the fibers
- 2) Assembly, including ease of assembly, accuracy of registering the fibers and time of assembly
- 3) Cost (both part cost and assembly cost)

Option (2) has appeal by way of its structural integrity, except for its protection of the fibers (a consequence of having to thread the fibers within the extrusion, where they are easily snagged). However, I am now working on a next-generation manifold design at this time that attempts to capture a good degree of the structural appeal of option (2), but still enables threading external to the module.

Our data to date indicates that option (1) dominates in the assembly category. We have documented time & motion studies that prove that it is possible to accurately thread the manifold in about 30 minutes (with little experience or refinement). I am of the opinion that option (2) can't compete in this regard, but I am open to hearing the opinions of others.

My "engineering estimate" is that the cost of the two designs is overall close. The average individual part cost of option (1) is higher than option (2), but option (2) requires more parts (it needs 31 fiber guides whereas option (1) has two fiber guides). However, the assembly cost of option (2) is much higher: the interior cell walls have to be cut away, the 31 fiber guides have to be installed, "snout" mounting is complicated, and threading is challenging. Therefore, my engineering judgement tells me that option (1) is ultimately the winner in the cost category.

Therefore, my plan is to continue development of option (1), but include features of the robust structure of option (2) in its re-design. Therefore, option (2) served a valuable purpose, but it doesn't appear

to me that further development of it is justified. But I again welcome input on this regard.

Again, we will have the "next generation" design ready and prototyped to coincide with the delivery of the first extrusions. As explained in my previous message, I believe we want to include time to revise the end seal designs to incorporate what we learn from having the real extrusions in hand.

Hans Jostlein's Comments.

(My comments will follow the order in Tom's description above)

The main thrust of Tom's preference is assembly time. He states correctly that we have not made a time and motion study of option 2. That does not mean we are completely without data.

There are several steps.

a. The notching of the extrusion webs.

I have timed myself for hand-punching holes in the webs. It took about 90 seconds to punch 31 holes with a manual punch. With a pneumatic hand punch (such as the one we used on the Dzero muon chambers where we punched large notches into 0.100" thick aluminum webs) this should take not any more time, but let's pad it to 2 minutes per extrusion (all 31 notches).

b. Gluing the neck

This is a molded part (mocked-up on my model by a notched section of PVC pipe) that is epoxied onto the extrusion. It is self-fixturing. The time will be mostly spent in mixing the epoxy. If multiple extrusions are done at one time, it will take about 2 minutes for gluing.

c. Fiber threading

As my model showed the fiber feed plate/ electronics box base is held a few inches away from the end of the neck. Fibers are blown in as in option one. The two ends of the first fiber (nearest the neck) is fed through the neck and threaded through the first two holes of the feedthrough.

I do not understand the comment about "working inside the module" and "fiber snagging".

In option 2 one reaches a little bit into the open end of the extrusion, just enough to feed the ends of a blown fiber loop through the neck.

I also do not understand the comment about "accuracy of registering the fibers". The only thing that matters is that each fiber pair ends up in the correct hole in the feedthrough. The pathway in between is irrelevant.

In option 2 one avoids operations that can be hazardous to the fiber, such as snapping them into the guide plate and into the holders, and using glue or hot melt adhesives to hold them.

Now the next fiber is blown in. The little molded fiber chute is slipped over the first web, the fiber ends fed through the neck, and inserted into the next pair of holes. The whole process takes longer to describe than to do. It is repeated until the last fiber ends are inserted.

d. Fiber protection

Because fibers are fed sequentially, there is no need for fiber routing; it is almost impossible to mis-insert a fiber. The fiber chutes are there to avoid fiber stress when an empty extrusion is held vertically, and the fiber weight pulls on the fibers. The chutes make it un-necessary to hold the fibers in other ways (e.g. glue), which may pose risks to the fibers.

With properly designed fiber chutes, no additional protection is needed.

We have, however, as design (part of the model) for a closure strip that snaps into the chutes to confine fibers to a small area. These strips should not be needed.

e. Closing the neck

When all fibers are in, one applies epoxy to the groove in the fiber plate and glues it to the neck.

This is also a self-fixturing joint and it is a groove-tenon “trapping” joint, not a single-lap joint.

f. Testing

At that time it is easy to attach a tester that measure fiber attenuation and verify correct fiber placement (if desired), e.g. using a video camera and a light source that is moved (by hand) from cell to cell. If problems such as broken fibers are found, they can be readily repaired.

g. Facing off: As with option 1, the fiber feedthrough will be faced off with a portable diamond cutter.

h. Closing the top plate. The top plate is almost identical to the bottom closure plate. It also has glue-trapping grooves and is self-fixturing.

Comparison of options 1 and 2, from my perspective:

a. Parts

This design has three types of parts:

--the neck, a molded part with a maximum dimension of about 8 inches, is a very simple shape, similar to a notched piece of PVC pipe

-the fiber chutes. There are 31 of them. Each has a maximum dimension of less than 2 inches and is uncomplicated.

fabrication. This got me thinking about the design of module components. I know that there were differences of opinion on how the bottom seal and the top manifold should be designed. How are the differing ideas going to be resolved? We only have 4-5 months to finalize the design and fabricate prototype parts for the ND prototype modules. Do we have a plan in place for evaluating different designs and coming to a consensus on the design? Are there tests or analysis that we should be doing now on the different concepts? I created a FEA model of the bottom seal that Tom had sent me which showed that under pressure the stresses were very small ($\sim 100\text{MPa}$). What other analysis should we do? Would it be a good idea to have a short workshop on this sometime soon?

Regards,

Vic

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